6059

INSTRUCTION MANUAL

OPERATING MANUAL
FOR
PANORAMIC ULTRASONIC ANALYZER
MODEL SB-15

AND ACCESSORIES

F-407

VIKING LABORATORIES INC.

SINGER
INSTRUMENTATION

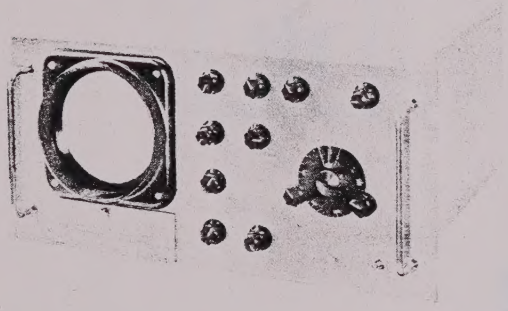
VIKING LABORATORIES INC.

SERIAL NUMBERS

SB-15:
G-15:
SW-1:
TW-1:
Accessory
Panel B:

OPERATING MANUAL
FOR
PANORAMIC ULTRASONIC ANALYZER
MODEL SB-15

AND ACCESSORIES



PANORAMIC
RADIO PRODUCTS, INC.

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CHAPTER I
INTRODUCTION

I-1. GENERAL.

This Operating Manual contains information concerning electrical and physical characteristics, applications, installation, and operation of the Panoramic Ultrasonic Analyzer, Model SB-15 and accessories.

No attempt to operate the equipment should be made until the user is thoroughly familiar with the information contained in Chapter III, OPERATING INSTRUCTIONS.

I-2. APPLICATIONS.

The Panoramic Ultrasonic Analyzer Model SB-15 is designed for spectrum analysis of complex discrete signals (Fourier analysis) and analysis of noise spectra in the frequency region of 200 cps to 525 kc. However, the equipment is usable from 100 cps to approximately 600 kc without serious degradation of the specifications.

The equipment provides an automatic, visual presentation of the frequency and amplitude of signals present in the frequency region of 100 cps to 600 kc for such studies as harmonic content, cross-modulation products, filter and transmission-line checks, ultrasonic vibration measurement, medical studies, and telemetry-channel monitoring.

The designed versatility of the unit permits selection of center frequency, sweep width, sweep rate, intermediate-frequency bandwidth, and type of amplitude scale. For convenience, the equipment also can be operated at a one-cps sweep rate with the if bandwidth automatically adjusted, when the sweep width is changed, so as to maintain approximately optimum resolution. The equipment enables the selection and detailed analysis of narrow bands which may contain signals separated by as little as 100 cps.

Once the norms for an application are established, nonprofessional personnel in the laboratory or factory easily can use the equipment to provide a graphic visualization of spectrum content. Yet the equipment is critically designed for laboratory investigations on the research and development level.

The equipment can be used to display modulated signals to measure energy distributions and to look for such effects as unwanted or excessive modulations, linearity of deviations, hum and noise, and otherwise undetectable parasitic oscillations. Other dynamic phenomena such as crowded communications

channels, oscillator or carrier instability, and noise spectra can be studied. Both the direction and magnitude of changes caused by deliberate or random change of circuit or operating parameters, mechanical shocks, environmental changes, etc. can be seen instantly.

The scope and facility of measurement with the Model SB-15 can be extended by using it in conjunction with certain compatible Panoramic and commercially available equipments.

+ The amplitude-versus-frequency response of systems and devices can be determined in the frequency region between 100 cps and 600 kc using the accessory Panoramic Ultrasonic Response Indicator, Model G-15.

+ To insure proper representation of the static response characteristics of sharply attenuating networks, the Panoramic Triangular Wave Generator Model TW-1 is recommended. Generating a continuously adjustable, linear, bi-directional time base, the TW-1 scan rate is adjusted downward until there is coincidence between the curves resulting from the forward and reverse scan. The trace at coincidence correctly represents the response characteristic of the network under test.

+ To plot power spectral density, provision is made in the Model SB-15 for connection of the Panoramic Power Spectral Density Analyzer, Model PDA-1.

+ To facilitate comparison of two input signals (comparing two similar test signals; comparing a test signal to a standard, known signal; etc.) the Panoramic Signal Alternator Model SW-1 can be used to alternate the two inputs to the Model SB-15.

+ To make permanent ink-on-paper recordings of analysis, the Panoramic Recorder Model RC-3a can be used with the Model SB-15.

+ A Polaroid-type oscilloscope camera suitable for screen photography with the Model SB-15 may be obtained from Panoramic Radio Products, Inc.

+ To drive auxiliary indicators, the Model SB-15 provides auxiliary vertical and horizontal outputs.

+ To synchronize the Model SW-1, camera shutters, and/or auxiliary indicators, a pulse output is provided by the Model SB-15. This pulse output is in synchronism with the sweep of the Model SB-15.

I-3. GENERAL DESCRIPTION.

The Panoramic Ultrasonic Analyzer is a scanning heterodyne instrument. It automatically provides a visual, two-dimensional display of the frequency components of a complex wave in any selected 1 kc to 200 kc segment of the region between 100 cps and 600 kc, on the screen of long-persistence, flat-faced cathode-ray tube, as vertical deflections distributed horizontally in order of component frequency. Note that while the equipment response is "flat" between 200 cps and 525 kc, it is usable between 100 cps and 600 kc. The frequency presentation is linear. The height of a given deflection indicates the relative magnitude of its corresponding frequency component.

The Model SB-15 consists basically of a calibrated input attenuator, a band-pass filter, a phase splitter, a sweeping oscillator, a balanced modulator, an intermediate-frequency-section attenuator, variably selective intermediate-frequency amplifiers, a detector, vertical and horizontal deflection amplifiers, a sawtooth generator, a cathode-ray tube indicator, and a self-contained power-supply section.

The sweeping oscillator progressively heterodynes, in order of frequency, with the signals in the frequency region of 100 cps to 600 kc at the output of the phase splitter to produce, among the products of mixing, a 1.5-mc sum frequency which is applied to the 1.5-mc intermediate-frequency section. A balanced modulator is employed to eliminate even-order modulation products and prevent passage of the sweeping-oscillator frequency into the if section. The output voltage of the if section is proportional to the amplitude of the sampled portion of the input signal. This output is detected, amplified, and applied to the vertical deflection plates of the cathode-ray tube. The vertical deflection appears at a definite location along the horizontal axis according to signal frequency, since a common sawtooth voltage source is used for both the sweeping oscillator and the horizontal deflection of the crt beam.

Oscillator sweep is obtained with a sawtooth-modulated reactance-tube circuit which controls the frequency of the sweeping oscillation. A calibrated SWEEP WIDTH control varies the amplitude of the modulating sawtooth to permit selection of any sweep width from 1 kc to 200 kc. A calibrated CENTER FREQUENCY control tunes the sweeping oscillator to permit selection of any center frequency between 0 and 500 kc.

In order to satisfy a very broad application range, the SB-15 incorporates independent SWEEP WIDTH, IF BANDWIDTH, and SWEEP RATE controls. For example, there are cases where high probability of signal intercept is paramount. This requires short scan intervals; hence, the variable SWEEP RATE control is set for a fast scan rate, the SWEEP WIDTH is set for the width of spectrum to be examined and the IF BANDWIDTH control is set to obtain a suitable intermediate-frequency bandwidth for the selected scanning velocity (product of sweep width and sweep rate). In other instances, for statistical

purposes, it may be necessary to scan slowly yet maintain a broad intermediate-frequency-section bandwidth.

In situations where a one-cps sweep rate with optimum resolution is indicated, setting the front-panel IF BANDWIDTH control to the AUTO position links the SWEEP WIDTH and IF BANDWIDTH controls such that approximately optimum resolution is maintained as sweep width is changed.

Three different amplitude scales can be selected: a linear scale calibrated in 10 divisions, a logarithmic scale calibrated from 0 db to -40 db in 5-db steps (extendable 20-db more by using the front-panel IF ATTENUATOR control), and an expanded scale wherein one screen division of the linear amplitude scale represents approximately 0.25 db. The latter scale is particularly useful for critical amplitude comparison between signals of almost similar amplitudes.

The Model SB-15 is packaged as a compact, self-contained unit designed for mounting in a standard, 19-inch, electrical-equipment rack.

Screen observations and photography are facilitated by providing a flat-faced cathode-ray tube (type 5ADP7), edge lighting for the calibrated crt screen, and a camera mounting bezel.

The regulated internal power-supply section operates from a 100- to 130-volt, 60-cps power source. On special order, a power-supply section which operates from a 50-cps source can be supplied.

I-4. EQUIPMENT SUPPLIED.

Description	Quantity
Model SB-15 including self-contained power supply	1
Line cord, ac, 3 wire, with adapter for 2-wire power line, Panoramic No. W3033	1
Mating Fitting for front-panel INPUT receptacle	1
Alignment Tool, Walso No. 2543 or equivalent	1
Wrenches for socket head screws	3

I-5. ELECTRICAL CHARACTERISTICS.

a. Frequency Range.

Any selected 1-kc to 200-kc portion of the range between 100 cps and 600 kc.

b. CRT Screen Calibrations.

(1) Amplitude Calibrations.

The screen has a linear amplitude calibration on the right side of the scale (1.0 to 0 in divisions of 0.1) and a logarithmic amplitude calibration on the left side of the scale (0 DB to -40 DB in 5-db divisions). When the front-panel switch AMPLITUDE SCALE is set to LOG, the logarithmic calibrations are used. When this switch is set to the LIN or EXP position, the linear calibrations are used. The linear calibrations are indicated by horizontal lines, the logarithmic calibrations by dots. (If so ordered, a calibrated screen can be supplied with horizontal lines for the logarithmic calibrations and dots for the linear calibrations.)

(2) Frequency Calibrations.

The screen has a linear frequency calibration scale, each division corresponding to one-tenth of the sweep width selected with the SWEEP WIDTH dial. This scale, called SWEEP WIDTH FACTOR, is calibrated from +0.5 to -0.5 in 0.1 divisions.

c. CENTER FREQ Dial Calibrations.

The CENTER FREQUENCY dial is calibrated from 0 to 500 KC in 20-kc divisions.

d. SWEEP WIDTH Dial Calibrations.

The SWEEP WIDTH dial is calibrated from 1 KC to 200 KC.

e. Input Amplitude Range.

NOTE: The nominal voltage required for full-scale deflection in the following chart is given for the maximum clockwise position of the IF BANDWIDTH control, a 200-kc sweep width, and a 30-cps sweep rate. Changing the setting of the IF BANDWIDTH, SWEEP WIDTH, or SWEEP RATE control may change the voltage required for full-scale deflection. This voltage is also somewhat dependent on the setting of the CENTER FREQUENCY dial (flatness).

Nominal input rms voltage required for full-scale deflection on the LIN amplitude scale.*			
INPUT ATTEN, STEP	IF ATTEN		
	0	20	40
0	200 uv	2,000 uv	20,000 uv
20	2,000 uv	20,000 uv	200,000 uv
40	20,000 uv	200,000 uv	2 volts
60	200,000 uv	2 volts	20 volts

f. Relative Voltage Accuracy.

±0.5 db for any frequency segment 200 kc wide or less throughout the frequency range of 200 cps to 525 kc.

Residual harmonic products of a single-frequency input of maximum allowable voltage on any input voltage range are suppressed by at least 60 db. Residual cross-modulation products of two equal-amplitude single-tone inputs of maximum allowable voltage on any input voltage range are suppressed by at least 60 db. Maximum allowable voltages are given in III-4b(2).

g. Amplitude Scales.

(1) Logarithmic, calibrated from 0 DB to -40 DB in 5-db steps.

(2) Linear, calibrated from 1.0 to 0 in 0.1 steps.

(3) Expanded, wherein one linear division is approximately 0.25 db.

h. Resolution.

Resolution is defined as the frequency separation of two signals of equal deflection amplitude, the deflections of which intersect 30% down from their peak amplitudes. Best resolution obtainable for any scanning velocity (sweep rate x sweep width) is approximately 1.8 times the square root of the scanning velocity.

i. Sweep Rate.

The sweep rate is adjustable continuously from 1 cps to 60 cps with the

* These voltages apply for the minimum setting of INPUT ATTEN, CONT. At the maximum setting of this control, an approximately 20-db increase of voltage is required for full-scale deflection on the LIN amplitude scale.

SWEEP RATE control. The sweep may be either free running, or synchronized with the ac power line, or externally synchronized.

j. Input Impedance.

The input impedance is 50,000 ohms.

k. Power Requirement.

The power required is 170 watts at 100 to 130 volts, 60 cps. On special order, the equipment can be supplied to operate from a 50-cps source of power.

I-6. PHYSICAL CHARACTERISTICS.

Model SB-15 ---------- 8-3/4 inches high x 19 inches wide (chassis is 16 inches wide) x 19 inches deep (including 1-1/4-inch knob projection and 1-3/8-inch projection of ac power plug).

AC Line Cord ---------- 5 feet long.

Weight of Model SB-15 - 45 pounds.

The front panel of the Model SB-15 and accessories are finished with a Munsell N-4.5 smooth gray enamel unless otherwise ordered.

I-7. TUBE COMPLEMENT.

CIRCUIT REFERENCE SYMBOL	TUBE TYPE	FUNCTION
V101	6146	Series Regulator (B+ Supply)
V102	12AX7	Regulator Control Tube (B+ Supply)
V103	5651	Voltage Reference (B+ Supply)
V104	12AX7	Regulator Control Tube (B+ Supply)
V105	5651	Voltage Regulator (-87 Volt Supply)
V201	12AU7	A: Vertical Amplifier B: Vertical Phase Inverter-Amplifier

CIRCUIT REFERENCE SYMBOL	TUBE TYPE	FUNCTION
V202	12AU7	A: Horizontal Amplifier B: Horizontal Phase Inverter-Amplifier
V203	5ADP7	Visual Indicator (Cathode-Ray Tube)
V301	12AT7	Sync Amplifier
V302	6U8	A: Sawtooth Generator B: Sawtooth-Generator Output Cathode Follower
V401	5U8	High-Voltage Regulator
V402	5642	Positive High-Voltage Rectifier
V403	1X2A	Negative High-Voltage Rectifier
V404	5AQ5	High-Voltage RF Oscillator
V501	6AB4	Input Cathode Follower
V502	12AY7	Input Amplifier
V503	6AB4	Phase Splitter
V504	5879	P/o Balanced Modulator
V505	5879	P/o Balanced Modulator
V506	12AX7	Marker Oscillator
V601	6AB4	Reactance Modulator
V602	6AB4	Sweeping Oscillator
V603	12AT7	Sweeping-Oscillator Output Limiter
V701	6AW8A	A: First IF Amplifier B: First Crystal Filter
V702	12AT7	First Selectivity-Control Tube
V703	6AW8A	A: Second IF Amplifier (Untuned) B: Second Crystal Filter

CIRCUIT REFERENCE SYMBOL	TUBE TYPE	FUNCTION
V704	12AT7	Second Selectivity-Control Tube
V705	6CB6	Third IF Amplifier
V706	6AU6	Fourth IF Amplifier
V707	6AL5	Detector

I-8. TERMS AND DEFINITIONS.

a. Panoramic Reception is the simultaneous visual reception of one or several frequency sources whose frequencies are distributed over a continuous portion of the frequency spectrum. This definition distinguishes panoramic reception from the conventional reception which can be either visual, aural, or both. The main distinction between panoramic and uni-signal reception is the following: Panoramic reception is periodic reception over a wide range of the spectrum. Each signal is received at fixed, rapid intervals, for a short period of time. At higher sweep rates, these signals are received so rapidly as to appear to be continuous on the crt screen because of the persistence of the screen material and retentivity of vision. Uni-signal reception is continuous reception, of the one signal at a time, over a very narrow range of the spectrum.

b. Sweep Width is the frequency range (frequency at left side of screen to frequency at right side of screen) measured in cycles, kilocycles or megacycles, which can be observed at any given center frequency.

c. Frequency Sweep Axis is the line along which the frequency is measured and which can be calibrated in frequency according to the setting of the SWEEP WIDTH and CENTER FREQ controls.

d. Center Frequency is the frequency corresponding to the horizontal center of the calibrated screen and the indication under the calibration mark on the fiducial of the CENTER FREQ dial.

e. Resolution is defined as the frequency difference between two signals of equal deflection amplitude, when their intersection is 30% down from peak. This characteristic corresponds to selectivity in ordinary receivers. The smaller this frequency difference, the better is the resolution.

f. Sweep Rate is the number of times per second the electron beam sweeps across the cathode-ray tube.

g. Deflection Amplitude is the height of a given signal deflection measured from the baseline to the top of the deflection.

h. Scanning Velocity is the product of the sweep rate and the sweep width.

Scanning Velocity = Sweep Rate (sweeps/sec) X
Sweep Width (kilocycles/sec/sweep)

= kilocycles/sec^2

CHAPTER II
INSTALLATION

II-1. UNPACKING AND INITIAL INSPECTION.

This instrument has been tested and calibrated before shipment. Only minor preparations are required to put the instrument in operation.

If damage to the case is evident when delivery is made, have the person making the delivery describe the damage and sign the notation on all copies of the delivery receipt.

Most public carriers do not recognize claims for concealed damage if such damage is not reported within fifteen days after delivery. All shipping containers should be opened and the equipment inspected before fifteen days elapse.

If damage is found when the equipment is delivered, whether concealed or obvious, call or write the carrier and ask that an inspection be made by their agent. Although the carrier is liable for any damage in the shipment, Panoramic Radio Products, Inc. will assist in describing and providing for repair or replacement of damaged items.

Be careful in unpacking and handling the equipment to avoid damage or undue exposure to the elements. Check the contents against the packing list and Chapter I, Section 4, to avoid loss of parts in the packing material.

The equipment is shipped with all its tubes and crystals already installed. Check that tubes, crystals, and other "pluck-out" components are well seated.

II-2. MOUNTING.

The equipment is designed for mounting in a standard, 19-inch, electrical-equipment rack. Slots on the sides of the front panel are provided for mounting the equipment to the front of the rack.

The unit should be located for effective ventilation, in an area where the ambient light is not excessively bright. Areas with a high level of electrical disturbance should be avoided. A convenient source of suitable ac power (see Section II-3) is required.

II-3. INTERCONNECTING PROCEDURE.

The equipment is normally supplied for connection to a 100- to 130-volt, 60-cps

power source. On special order, it can be supplied for operation from a 100- to 130-volt, 50-cps source. The nominal power source required is marked (eg, 115 v, 60 cps) near the ac power receptacle at the rear of the equipment. Be sure that the correct power source is provided.

To use the equipment it is only necessary to connect the supplied ac line cord between the ac power receptacle at the rear of the equipment and the source of power. A three-wire cord is supplied. If the power source does not accommodate a three-wire cord (center pin grounded), then the supplied adapter should be used. If the adapter is used, the ground wire of the adapter should be connected to a suitable external ground.

Be sure that the shorting plug is securely plugged into the TW-1 AND ACCESS receptacle at the rear of the equipment. Signal input is connected to the front-panel INPUT receptacle. The supplied mating fitting for this receptacle can be used to fabricate a convenient input cable. This cable should be fabricated from shielded cable to minimize stray pick-up.

II-4. INSTALLATION ADJUSTMENTS AND CHECKS.

NOTE: Refer to Chapter III for details concerning operating techniques.

a. Set the following front-panel controls to the listed positions.

FREQ. MARKERS	OFF (up)
IF ATTEN	40 DB
INPUT ATTEN, STEP	20 DB
INPUT ATTEN, CONT	Completely clockwise
AMPLITUDE SCALE	LOG
SWEEP WIDTH Dial	200 KC
IF BANDWIDTH	MAX
CENTER FREQ. Dial	200 KC
CAL-SYNC SEL	LINE
SYNC AMPL	Completely counterclockwise
VIDEO FILTER	Switched off (completely counter-clockwise position)
SWEEP RATE	Completely clockwise

Open the hinged cover beneath the crt, thus exposing the INT, FOCUS, V POS, and H POS controls.

b. Switch on the equipment by rotating the SCALE ILLUM control fully clockwise. The crt screen edge lighting should go on immediately.

Within 30 seconds, a dot should appear on the screen and within a few seconds start to sweep across the screen.

If nothing appears on the screen, turn the INT control clockwise. If nothing appears on the screen, turn INT completely clockwise and adjust V POS. Then reduce INT for a suitable trace. Adjust FOCUS for a sharp trace and adjust V POS so that the trace is coincident with the base of the calibrated scale. Adjust H POS if the trace does not extend beyond the ends of the calibrated scale.

c. Rotate SWEEP RATE control throughout its range noting that clockwise rotation increases the rate.

Turn CAL-SYNC SEL to CAL. The baseline will become a series of sine waves, the number of which indicates the sweep rate. The sweep rate is determined by counting the number of cycles on the screen and dividing this number into 60.* (Eg, if there are 3 cycles on the screen, the sweep rate = 60 divided by 3 = 20 cps.) To synchronize the sweep to the power line, adjust the SWEEP RATE control such that the appropriate number of cycles appropriate number of cycles appear on the screen and are almost stationary with a slight drift to the left. Rotate the SYNC AMP control until the cycles become stationary. Further rotation of the SYNC AMP control will tend to shorten the size of the line. Minimum sync amplitude consistent with good synchronism is the best setting. Note that at low sweep rate, it is easier to count sweeps, using a stop watch for timing, than to count cycles.

Set SWEEP RATE and SYNC AMPL for a stable 20-cps rate (3 cycles on screen). Return the CAL-SYNC SEL to the LINE position.

d. Turn the CENTER FREQ dial to 0. A rise or deflection of the baseline around the center of the screen may or may not be present. The presence of this pip indicates an unbalanced condition in the balanced modulator. Manipulate the R BAL and G BAL controls alternately to minimize this deflection. Set the IF ATTEN to 20 DB and rebalance. Set the IF ATTEN to 0 db and rebalance. With each setting of the IF ATTEN from 40 DB to 0 DB the balance controls will become more critical. It may not be possible to completely eliminate the deflection on all settings in which case proper balance is indicated by the presence of a minimum amplitude double hump that resembles an "m".

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* 50 if the power-line frequency is 50 cps.

e. Set FREQ MARKERS to ON. Center any one of the marker pips with the CENTER FREQ control and adjust INPUT ATTEN, CONT and/or IF ATTEN so that this marker pip is approximately full scale. Gradually reduce the SWEEP WIDTH to minimum, maintaining the pip in the center of the screen with the CENTER FREQ control. Return to 200-kc sweep width. If the pip is not in the center of the screen (top of the pip coinciding with the center vertical line), set it in the center with the H POS control.

f. Check the IF BANDWIDTH control by reducing the sweep width until the base of a centered, full-scale, 100-kc signal or marker pip occupies approximately one-third of the screen. Then slowly turn IF BANDWIDTH counterclockwise. The pip width should decrease. At the same time there may be a change in pip height. Maintain a full-scale pip by changing the input level or adjusting the attenuators. As IF BANDWIDTH is turned counterclockwise small convolutions of "ringing" will appear on the trailing (left) edge of the pip. Optimum resolution occurs when the notch between the signal pip and the ringing pip nearest the signal pip is at its lowest point. Section III-4d contains a more extended discussion of the variation of screen presentation with change in IF BANDWIDTH setting.

The AUTO position of the IF BANDWIDTH control is checked by setting the sweep rate to 1 cps. Adjust the equipment for a centered, full-scale pip at maximum sweep width. With the IF BANDWIDTH control on the AUTO position, the bandwidth (as indicated by the comparative width of the pip) should vary automatically with reduction of sweep width, maintaining optimum resolution down to approximately minimum sweep width.

g. Remove the input signal and change the control settings as follows:

SWEEP WIDTH ---------- 20 KC
CENTER FREQ ---------- 0 KC
AMPLITUDE SCALE ---------- LOG
IF ATTEN ---------- 0 DB
INPUT ATTEN, CONT -------- Completely counterclockwise
FREQ. MARKERS ---------- OFF

Using the R BAL control, set the deflection which occurs near the center of the screen at full scale. Center the deflection using the CENTER FREQ control. When centered, if the calibration mark on the dial does not coincide with the mark on the fiducial, rotate the dial (not the knob) until coincidence occurs. Adjust R BAL and G BAL for minimum deflection at the center of the screen. Turn the FREQ MARKERS switch to ON and adjust the IF ATTEN and the INPUT ATTEN, CONT for approximately 1/2 scale deflection of the pip which appears on the right

screen limit. This is the first marker pip. Rotate the CENTER FREQ control towards a higher frequency counting marker pips. For all even numbered marker pips (second, fourth, etc.), a calibration point of the CENTER FREQ control will be under the index line and the frequency will be the number of the marker pip times 10 kc.

h. Set the CENTER FREQ control to 95 kc and the SWEEP WIDTH control to 10 KC. A marker pip will be near the right and left screen limits. In the following checks, trim the CENTER FREQ control as required to center the marker presentation. Increase the sweep width. At each calibration point of the SWEEP WIDTH dial the sweep width will be the number of pips from left limit to right limit, minus one, times 10 kc. Eg, if there are 3 pips, the sweep width is: (3-1) x 10 kc = 20 kc. To check sweep widths below 10 kc, use a 100 kc signal which is amplitude modulated by an audio signal. Set the audio frequency such that the sidebands are at the left and right screen limit. The sweep width is then twice the audio frequency.

i. Check the amplitude scales using an input signal of variable and known amplitude and low distortion. Any convenient fixed CENTER FREQ and SWEEP WIDTH settings compatible with the generator frequency and pip readability may be used. Set the controls as follows:

AMPLITUDE SCALE	LIN
IF ATTEN	40 DB
INPUT ATTEN, CONT	Completely counterclockwise
INPUT ATTEN, STEP	20 DB
IF BANDWIDTH	MAX
VIDEO FILTER	Switched off (completely counterclockwise position)
SWEEP RATE	30 cps

A signal amplitude of .2 volts should result in an approximately full-scale pip. Adjust generator level if necessary for a full-scale pip. Change IF ATTEN to 20 DB and INPUT ATTEN, STEP to 40 DB. The pip should remain approximately full-scale. Repeat with IF ATTEN at 0 DB and INPUT ATTEN, STEP at 60 DB. Set IF ATTEN to 40 DB and INPUT ATTEN, STEP to 0 DB. Rotate INPUT ATTEN, CONT completely clockwise. The pip should be less than full-scale, indicating more than a 20-db range in this control. Return INPUT ATTEN, CONT to full counterclockwise and INPUT ATTEN, STEP to 20 DB. Adjust the input amplitude for a full-scale pip.

Switch AMPLITUDE SCALE to LOG. The pip amplitude should be in line with the 0 DB calibration dot on the left side of the calibrated crt scale.

Change IF ATTEN from 40 DB to 20 DB. Pip amplitude will increase to full scale. Intermediate crt screen calibration points on both the LIN and LOG positions of AMPLITUDE SCALE may be checked against known input levels.

Switch AMPLITUDE SCALE to EXP. Using INPUT ATTEN, CONT, obtain a full-scale pip. Decrease the input amplitude of the signal in 0.25-db steps. The pip amplitude should decrease approximately one linear division of the crt screen for each 0.25 db of reduction of input amplitude.

CHAPTER III
OPERATING INSTRUCTIONS

Haphazard operation or improper setting of controls can cause damage to the equipment and/or false or misleading results. Satisfactory results will be obtained if the equipment is operated carefully in accordance with the instructions found in this chapter.

For convenience, this chapter is divided into four sections.

Sections 1 and 2 describe the function of the operating and semi-adjustable operating controls. The controls listed in these two sections are the only controls required in operation. All other controls are used only in maintenance or service of the units. Such controls should not be adjusted by operating personnel but should be left to experienced service personnel.

Preliminary adjustments for operation are given in Section 3. For best results, the preliminary adjustments should be made with care and exactness each time the equipment is turned on.

The techniques of operation for various types of measurements are given in Section 4. The use of optional accessory equipment to extend the application of the equipment is discussed in Chapter IV. While it is not possible to cover all possible measurement problems, the general procedure can be adapted to specific problems. Our Applications Engineering Section is available for consultation and assistance when special or unusual measurement problems are encountered.

III-1. OPERATING CONTROLS.

The following controls are available to the operator. They are mounted on the front panel.

a. SWEEP WIDTH.

This control is used to set the width of the segment of the spectrum being analyzed. The SWEEP WIDTH is adjustable continuously between 1 kc and 200 kc as indicated by the associated calibrated dial.

The center frequency remains nominally constant as the sweep width is varied and vice versa.

b. CENTER FREQuency.

This control is used to determine the frequency that will appear at the center of the crt screen. The center frequency of the spectrum segment being analyzed is adjustable continuously between 0 and 500 kc.

The sweep width remains nominally constant as the center frequency is varied and vice versa.

c. AMPLITUDE SCALE.

Selection of a logarithmic (LOG position), a linear (LIN position), or an expanded (EXP position) amplitude presentation is accomplished with this three-position rotary switch.

The LOG position is used when the amplitude ratio of the frequency components is large. In this position, the calibration dots on the left side of the crt screen are used.* The screen calibration range is from 0 to -40 db in 5-db steps.

The LIN position is used when the amplitude ratio of the frequency components is smaller. The horizontal calibration lines on the crt screen are used in this position and are read on the right side of the crt screen.* The linear scale is calibrated in ten divisions.

In the EXP position, an expanded presentation is provided to facilitate close comparison between signals of similar amplitude. In this position, one screen division of the linear amplitude scale represents approximately 0.25 db.

d. SWEEP RATE.

This control provides continuously adjustable sweep rates between 1 cps and 60 cps. Clockwise rotation increases the sweep rate.

e. CAL-SYNC SEL.

This switch has three positions: CAL, LINE, and EXT. In the CAL position, the sweep rate may be calibrated and/or synchronized to the power

* If so ordered, a calibrated screen can be supplied with horizontal lines for the logarithmic calibrations and dots for the linear calibrations.

line. In the LINE position, the sweep may be synchronized with the power-line frequency. The EXT position permits sweep synchronism by means of a suitable signal connected to the SYNC IN receptacle (located on the rear of the unit). Sweep without synchronism (free-running sweep) may be obtained in all three positions by setting SYNC AMP completely counterclockwise.

f. SYNC AMP.

The amplitude of the sweep-synchronizing signal is adjusted with this control to provide proper crt beam sweep synchronism. Maximum amplitude occurs at the maximum clockwise position. A free-running sweep is obtained by setting the control completely counterclockwise.

g. IF BANDWIDTH.

The bandwidth of the intermediate-frequency section is adjusted with this control. Clockwise rotation increases the if bandwidth.

When the IF BANDWIDTH control is switched to the AUTO position and the SWEEP RATE control is set for a 1-cps rate, the equipment is conditioned to provide the correct if bandwidth for optimum resolution (defined in Section III-4d) at all settings of the SWEEP WIDTH control.

h. INPUT ATTENUATOR.

(1) STEP.

Clockwise rotation of this control gives a maximum of 60 db of attenuation of the input signal in 20-db steps.

(2) CONTINUOUS.

A full clockwise rotation of this control gives a minimum of 20 db attenuation to the input signal.

i. IF ATTENUATOR.

For any given setting of the INPUT ATTEN controls, this three-position switch provides 0, 20, or 40 db of additional attenuation.

j. VIDEO FILTER.

This control provides continuous adjustment of a smoothing filter located at the output of the detector. Clockwise rotation increases the degree of filtering. The control can be switched off in the extreme counterclockwise position.

When the equipment is being used to measure discrete signals, the control is used to reduce noise, beats between signals close in frequency, etc. When the equipment is being used to measure noise spectra, the control is used to obtain averaging of the noise spectrum envelope.

k. R BALance and G BALance.

These controls are used to suppress the internally generated deflection which may appear on the crt screen when the CENTER FREQUENCY dial is at or near 0.

l. FREQUENCY MARKERS.

In the down position this switch turns on the internal frequency markers. These marker frequencies occur every 10 kc.

m. SCALE ILLUM (POWER OFF).

This control is rotated clockwise to switch on the power to the equipment. Continued clockwise rotation will increase the scale illumination of the calibrated crt screen.

III-2. SEMI-ADJUSTABLE OPERATING CONTROLS.

These controls are used to set the operation of the crt and seldom require adjustment. For this reason they are located behind a hinged cover located below the crt. The cover is opened by turning the knurled, slotted, locking screw counterclockwise.

a. H POS.

This control is used to adjust the horizontal position of the crt baseline trace. Clockwise rotation shifts the trace to the right.

b. V POS.

This control is used to adjust the vertical position of the crt baseline trace. Clockwise rotation raises the trace.

c. FOCUS.

This control is used to adjust the focus of the crt trace.

d. INTensity.

This control is used to adjust the intensity of the crt trace. Clockwise rotation increases the intensity.

III-3. PRELIMINARY ADJUSTMENTS.

a. Set the following front-panel controls to the listed positions.

SWEEP WIDTH Dial	200 KC
CENTER FREQ. Dial	200 KC
IF BANDWIDTH	MAX
AMPLITUDE SCALE	LOG
IF ATTEN	20 DB
VIDEO FILTER	Switched off (completely counterclockwise position)

Be sure that the shorting plug is securely plugged into the TW-1 AND ACCESS receptacle at the rear of the equipment.

b. Switch on the power by rotating SCALE ILLUM clockwise. The crt screen edge lighting should go on immediately. Within 30 seconds, a dot should appear on the screen and within a few seconds start to sweep across the screen.

If nothing appears on the screen, turn the INT control (located under the hinged cover that is found below the crt) clockwise. (It may be necessary to adjust V POS to bring the baseline trace on the screen.) The INT control should be set at a minimum point of suitable visibility and the FOCUS control for the finest clear line. A later adjustment of FOCUS and INT may be required, since the appropriate settings are partially dependent upon the signal density. Do not use the INT control to compete with external light falling on the crt screen but rather reduce the external light or shield the screen.

Check the vertical and horizontal positions of the baseline trace. When viewing the crt screen, the eye of the observer should be along the axis of the crt at a distance of approximately 15 inches from the face of the crt. The screen calibrations have been made from this position. Hence, any other viewing position will introduce parallax error. See Figure III-1.

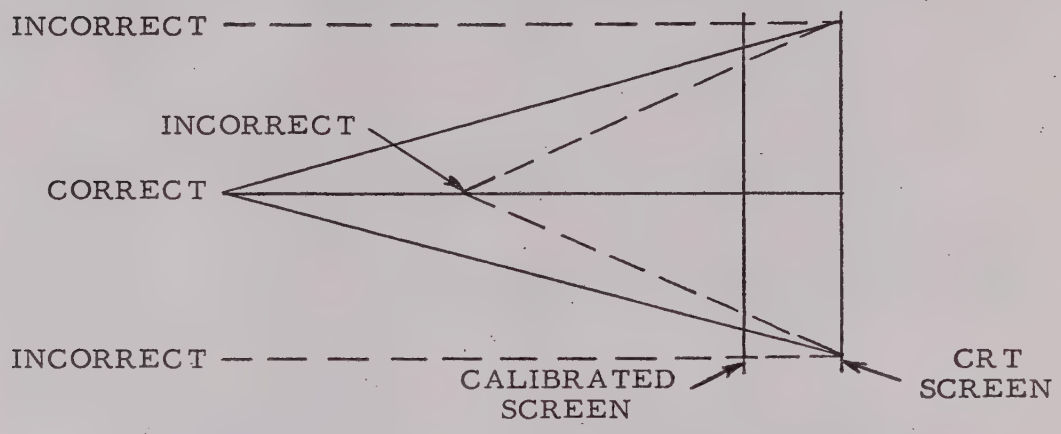

Figure III-1. Correct Viewing of CRT Screen.

If necessary, V POS should be set for coincidence of the baseline trace with the baseline of the calibrated crt scale. H POS should only be adjusted if the baseline trace does not fall to either side of the ends of the calibrated scale.

For wide-band analysis, the instrument may be used within a few minutes although adjustment may be required as the instrument warms up. For narrow-band analysis, it is advisable to wait a half hour to allow the unit to stabilize.

c. Set the CENTER FREQ dial to 0 and adjust R BAL and G BAL to minimize the zero pip that appears at the center of the screen.

d. Turn FREQ. MARKERS to ON. Center any one of the marker pips and adjust INPUT ATTEN, CONT and/or IF ATTEN so that this marker pip is approximately full scale. Gradually reduce the SWEEP WIDTH to minimum, maintaining the pip in the center of the screen with the CENTER FREQUENCY control. Return to 200-kc sweep width. If the pip is not in the center of the screen (top of the pip coinciding with the center vertical

line), set it in the center with the H POS control.

e. If desired, applicable installation checks (Section II-4) can be made. From this point, all control settings are dependent upon the input signal characteristics and the type of measurements to be made.

III-4. OPERATING TECHNIQUES.

Once the preliminary adjustments have been made, the instrument is ready for use. If the equipment is used during the warm-up period, frequency calibration adjustments may be necessary.

a. CLASSIFICATION OF INPUT SIGNALS.

Generally, input signals to the spectrum analyzer can be divided into two types: discrete and non-discrete. Discrete signals are periodic waveforms with frequency contents which do not vary appreciably with time. The internal markers of the equipment are typical of such a signal. Although there are several frequency components, each frequency is discernible as a separate pip providing the resolution of the spectrum analyzer is adequate for the frequency differences encountered. In practice, discrete signals are typical of periodic oscillation such as signal-generator and oscillator outputs and transducer outputs if a periodic vibration is encountered, for example, constant-speed rotating machinery with a well-defined resonant vibration. Non-discrete signals are typified by random noise in which the input frequency distribution must be considered as spread out over a band of the spectrum, rather than consisting of line spectra. Random signals vary with time but usually have a definable mean (rm level. Non-discrete signals are shown on the spectrum analyzer as a varying envelope of amplitude at each spectrum sample. Several scans through the noise input signal usually are adequate to establish a meaningful relative amplitude-versus-frequency analysis. The amplitude scales are equally valid for both random and discrete signals. However, the equipment sensitivity for discrete signals is different from that for random signals. Discrete signal levels should be compared to other discrete signal levels and random to other random levels when relative signal strengths are being determined. In a generally complex signal where both random and discrete signals are present, the spectrum analyzer will show on average the levels of the noise and the levels of the discrete signals correctly. That is, the random and discrete deflections on average would not change if one or the other were removed from the input signal.

Sections "b", "c", and "d" below give operating techniques for discrete-signal measurement. Section "e" gives operating techniques for noise measurements.

b. RELATIVE-VOLTAGE MEASUREMENTS OF DISCRETE SIGNALS.

(1) Set the following controls to the listed positions.

SWEEP WIDTH Dial ---------- 200 KC
CENTER FREQ Dial ---------- 0 KC
IF BANDWIDTH ---------- MAX
IF ATTEN ---------- 20 DB
AMPLITUDE SCALE ---------- LOG
VIDEO FILTER ---------- Switched off (Completely counterclockwise position)

(2) Connect the signals to be measured to the INPUT receptacle of the Model SB-15. A shielded cable should be used. Note that a mating fitting for the INPUT receptacle is supplied.

WARNING: Damage to the equipment may occur if the instantaneous peak input voltage exceeds 300 volts.

For correct results, the following limits on the instantaneous peak voltage of signals connected to the INPUT must be observed. Failure to limit the level to the indicated voltages may result in incorrect amplitude readings and indications of frequency components which are not present in the input signal. It should be noted, however, that even if large amplitude bursts do occur, if they are of very short time duration they can be ignored. They will cause spurious response for a very short period of time and thus will not appear on the crt for any significant length of time.

Maximum Instantaneous Peak Input Voltage		
INPUT ATTEN, STEP	INPUT ATTEN, CONT	
	Completely Counterclockwise	Completely Clockwise
0	30,000 uv	300,000 uv
20	300,000 uv	3 v
40	3 v	30 v
60	30 v	300 v

When evaluating the input level, it is necessary to measure the total amplitude present at the input in the frequency region for 0 to 600 kc whether related to the signals to be tested or not. The input amplitude should be measured with a broadband, fast-responding, peak-level indicator such as an oscilloscope.* If the presence of signals not related to the signals of interest are of sufficient level to overload the equipment, it is advisable to use appropriate filters to eliminate the unrelated signals.

As a rough check for overload, it should be noted that overload can be assumed to occur if, with the IF ATTEN set to 20 DB and AMPLITUDE SCALE set to LOG, pips greater than full scale result. This does not mean that if the pips are less than full scale overloading is not occurring.

Providing that the voltages indicated in the chart above are not exceeded, it is completely permissible to have crt deflections greater than full scale, thereby permitting study of low-level signals. The INPUT ATTEN, STEP and, if necessary, the INPUT ATTEN, CONT are set to avoid overload. The IF ATTEN is then set appropriate to the level of signals to be measured.

(3) Adjust R BAL and G BAL for maximum suppression of the zero-frequency pip. It should be noted that it is perfectly normal for the amplitude of the zero-frequency pip to vary with time. If the frequency region being examined is sufficiently remote from 0 that the zero-frequency pip is not on the screen, it is only necessary to be sure that the zero-frequency pip is less than full scale on the LIN scale when IF ATTEN is set to 0 DB. It is good practice to confirm this degree of suppression occasionally. If the equipment is used near enough to 0 that the zero that the zero-frequency pip is on the screen, greater care in suppression may be required. If the zero-frequency pip is below full scale on the LIN scale with IF ATTEN set to 0 DB and the signal pips do not tend to ride on the zero-frequency pip, if possible, adjust the equipment to improve the resolving capabilities (reduce the sweep width, reduce the sweep rate, and/or narrow the if bandwidth in accordance with III-4d). If improvement of the resolving capabilities does not separate

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* Amplitude overloading of the input is determined by the instantaneous peak voltage of the input signal. However, in cases in which the peak amplitudes are no greater than 1.4 times the rms amplitude, a broadband true rms voltmeter may be used instead of an oscilloscope if more convenient.

sufficiently the zero-frequency pip from the signal pips, adjust R BAL and G BAL for a suppression of the zero-frequency that is sufficient to prevent influence on the amplitude of the signal pips.

(4) Adjust the CENTER FREQ dial to bring the desired test signals on the screen. If a closer examination is required, the sweep width may be reduced.

(5) The spectrum analyzer can be adjusted to provide any sweep rate from 1 cps to 60 cps. The spectrum analyzer sweep rate can be adjusted for synchronism to the power line, synchronism to an external signal, or non-synchronism (free-running). When the CAL-SYNC SEL switch is set to the EXT position, the sweep can be synchronized to a suitable signal connected to EXT SYNC receptacle (rear apron of analyzer chassis). When the switch is set to the LINE position, the sweep can be synchronized to the power line. When the SYNC AMP control is turned completely counterclockwise, the sweep operates without synchronism. The technique of adjusting the sweep rate is given in paragraph II-4c.

The choice of appropriate sweep rate and mode of sweep synchronism of the spectrum analyzer is determined by the nature of the signals being studied. For example, when the test signals are sporadic in occurrence, it is desirable to operate the equipment at high sweep rates to increase the probability of intercepting the signal. On the other hand, one way to obtain better resolution is to decrease the sweep rate. When examining pulse spectra, increasing the sweep rate will reduce the number of pulse lines per scan. Thus, a high synchronous sweep rate permits examination for missing pulse lines. On the other hand, a low sweep rate will increase the number of pulse lines per scan thus giving better definition to the shape of the spectral distribution envelope. Examination of distributed spectra (for example, random noise) requires low sweep rates to obtain good definition (see "e" below).

In most applications the unsynchronized-sweep mode of operation provides more information than does the synchronized mode. However, it is often more convenient for viewing purposes to synchronize the sweep. For example, when examining a signal, unresolved modulations may be revealed as amplitude bobbing of the screen presentation when the sweep is not synchronous with the modulation frequency. Synchronizing the sweep to the modulation frequency will stop the bobbing. When viewing pulsed rf signals, unsynchronized sweep will result in the continuous shifting across the screen of the pulse lines. This results in better

definition of the spectral envelope. However, if examination for missing prf lines or determination of the pulse repetition frequency is desired, it is more convenient to synchronize the sweep to the pulse thereby causing a stationary pattern on the crt screen. Note that if the pulse is synchronized to the power line, synchronism is more easily provided by synchronizing the spectrum analyzer to the power line rather than to the pulse.

(6) The relative heights of the pip deflections on the crt screen are proportional to the relative amplitudes of the corresponding frequency components being analyzed, within the limits of flatness of response of the spectrum analyzer in the range of 100 cps to 600 kc. The specified flatness of response (see Section I-5f) will be applicable only if SWEEP WIDTH, SWEEP RATE, and IF BANDWIDTH are not changed. Changing the setting of these controls may change the height of crt deflections.

Best accuracy of amplitude ratio measurement is provided by the EXP position of AMPLITUDE SCALE, least accuracy by the LOG position.

Note that it is permissible to exceed full-scale pip height to examine low-level signals providing the equipment is not overdriven (see Section III-4b(2)).

To observe signals of comparable amplitude, AMPLITUDE SCALE should be set to LIN. The LIN scale of the crt screen is calibrated into ten divisions. The horizontal calibration lines are read at the right side of the screen.*

On the other hand, simultaneous examination of signals of wide divergence of amplitude will require the LOG setting of this control. In this position, the calibration range is from 0 db to -40 db in 5-db divisions as indicated by the dots on the left side of the screen.* Note that the LOG calibration does not hold when narrow pulses are measured.

When the range of signal amplitudes is less than 2 db and greater precision of measurement is required, the EXP position of the

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* If so ordered, a calibrated screen can be supplied with horizontal lines for the logarithmic calibrations and dots for the linear calibrations.

AMPLITUDE SCALE can be used. Here each linear calibration division represents approximately 0. 25 db.

(7) Signal levels too low to be analyzed in terms of the sensitivity of the equipment can be examined by amplifying them using a pre-amplifier of low noise and distortion and known gain. The output from the pre-amplifier must then be considered the signal being analyzed particularly in terms of overload.

(8) If noise, beats between adjacent signals, etc. make observations difficult, the VIDEO FILTER can be used to suppress such unwanted effects. However, if measurements permit, it is better to keep the control in the OFF position and adjust the equipment for better resolution (see Section III-4d) to eliminate beats between adjacent signals.

Clockwise rotation of VIDEO FILTER increases the amount of filtering. Excessive filtering will decrease the amplitude of pips on the screen and worsen resolution. The control, if used, should be adjusted for clearest picture with minimum loss of amplitude. It should be noted that the control has greatest useful effect at low sweep rates. At high sweep rates, the effect on the signal pips is too great for the control to be helpful.

c. FREQUENCY MEASUREMENTS OF DISCRETE SIGNALS.

(1) Use the same technique for placing the signals to be studied on the crt screen as is given in "b" above. Since pip shape is sharper on the LIN and EXP than LOG position of AMPLITUDE SCALE, the LIN and EXP positions provide a better ability to measure frequency than does the LOG position.

(2) The CENTER FREQ dial setting indicates the frequency of a pip at the center of the screen. Adding the reading of the SWEEP WIDTH dial times the crt screen SWEEP WIDTH FACTOR calibration point (preserving sign) over which the pip appears to the reading of CENTER FREQ dial represents the frequency of the component to which the pip corresponds. For example:

CENTER FREQ Dial Reading = 400 KC
SWEEP WIDTH Dial Reading = 100 KC
Pip appears over -. 2 division on crt screen.
Pip Frequency = 400 KC + 100 KC X (-. 2) = 400 KC-20 KC
= 380 KC

The internal frequency markers can be used to check the CENTER FREQ and SWEEP WIDTH dial calibrations. The marker consists of a 100-kc harmonically rich source modulated by a 10-kc harmonically rich source. The accuracy of the 100-kc marker source is ±.02% and the accuracy of the 10-kc modulating marker source is ±2%.* Using these markers to set precisely the center frequency and sweep width, it is possible to measure the frequency to ±2% plus the interpolation error. This is best done by removing the input signal to the SB-15, setting up the center frequency and sweep width using the markers, then reconnecting the signal and making measurements.

(3) If frequency measurements are required that are of greater accuracy than that permitted by the calibration accuracy of the dials and markers, a frequency-accurate signal may be connected to the input of the spectrum analyzer to determine the exact location of interesting frequencies. To do this, it is first necessary to remove the signals being measured or isolate them properly. More conveniently, the Panoramic Signal Alternator, Model SW-1, may be used to alternate the test signal and the calibration signal, thereby avoiding interference between the two and permitting an exact optical overlay of the two signals.

(4) If noise, beats between adjacent signals, etc. make observations difficult, the VIDEO FILTER can be used to suppress such unwanted effects. The technique of adjusting the VIDEO FILTER is given in III-4b(8).

d. NARROW-BAND ANALYSIS OF DISCRETE SIGNALS. (MEASUREMENT OF SIGNALS CLOSELY SPACED IN FREQUENCY.)

At full sweep width test signals or a carrier and its sidebands, having a small frequency difference, tend to have their corresponding deflections merge into and mask each other. The ability of the equipment to separate individual signals (resolution) depends upon two factors: the scanning velocity (product of sweep rate and sweep width) and the bandwidth of the intermediate-frequency section of the equipment. For any given scanning velocity, there is a complementary if bandwidth for optimum resolution.

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* The manner of marker generation results in the generation of a particular nominal frequency in several different ways. For example, 150 kc is generated as the sum of 100 kc and the fifth harmonic of 10 kc and also as the difference of 200 kc (second harmonic of 100 kc) and the fifth harmonic of 100 kc. Because of the tolerances involved, the multiple generation of a particular frequency occasionally may result in a marker pip which wobbles on the crt screen. This rarely happens and can be ignored.

The scanning velocity is reduced by increasing the sweep period (reducing the sweep rate) and/or decreasing the spectrum width scanned within a given time (reducing the sweep width). Reducing the scanning velocity improves resolution (improves the ability of the equipment to separate closely-spaced frequency components).

The IF BANDWIDTH control is used to adjust the intermediate-frequency-section bandwidth. Counterclockwise rotation of this control narrows the width of the if section. It should be noted that, as this control is adjusted, there will be some degree of change in the sensitivity of the equipment. Narrowing the if bandwidth improves resolution until the point of optimum resolution (see III-4d(5)) and the definition below) is reduced. Beyond this point, further narrowing of if bandwidth worsens resolution.

Optimum resolution is defined as approximately equal to 1.8 times the square root of the scanning velocity. This should be used as a guide to determine whether or not a given set of signals can be resolved, and, if they can, at what control settings. For example, if a given number of equal amplitude sidebands each a fixed frequency apart are to be measured, the product of number of sidebands times frequency separation determines the sweep width required. The frequency separation of the sidebands determines the resolution necessary to separate the sidebands. From this and the formula above the fastest sweep rate for this resolution can be calculated. For signals whose amplitudes are unequal, the above becomes inapplicable. If a signal of small amplitude is close in frequency to a signal of large amplitude, the pip due to the small signal will be influenced by the presence of the large pip. In effect, the small pip will ride on the skirt of the large pip (the amplitude-versus-frequency response of the intermediate-frequency section being bell-shaped). As the signals are separated in frequency, the error becomes less.

To increase the resolution capabilities by reducing sweep width, narrowing the if bandwidth, and increasing scanning time, use the following procedure:*

(1) Set the IF BANDWIDTH control completely clockwise, the position for broadest if bandwidth.

(2) Adjust the CENTER FREQUENCY control so that the desired band of signals is at the center of the screen.

* When convenient, the SWEEP RATE can be set to 1 cps and the IF BANDWIDTH set to AUTO. The equipment is then conditioned to automatically adjust the if bandwidth for optimum resolution as the sweep width is varied.

(3) Spread the band of signals across the screen by turning the SWEEP WIDTH control counterclockwise. Note that at reduced sweep width each frequency calibration mark on the screen represents a frequency separation equal to one-tengh of the reduced sweep width.

(4) Turn the IF BANDWIDTH control counterclockwise until individual signals are most clearly resolved. If the signals are not resolved, a slower sweep rate will be required. Optimum resolution can be recognized by the nature of the ringing pulses that will appear on the trailing edge of the signal pip as optimum resolution is approached. See Figure III-2 and subparagraph (5) below. Ringing can be seen more easily with the VIDEO FILTER control in the extreme counterclockwise position (switched off).

NOTE: Rotation of the IF BANDWIDTH control may result in increased or decreased pip height. Pip amplitude may be returned to suitable level with the STEP and CONT INPUT ATTEN controls. Turning the IF BANDWIDTH control counterclockwise after optimum resolution is reached will decrease the resolving power and result in greatly reduced sensitivity.

(5) If the resolution adjustment results in practically complete separation of signal pips maximum resolution can be recognized by the presence of ringing pulses on the trailing edge of the pip.

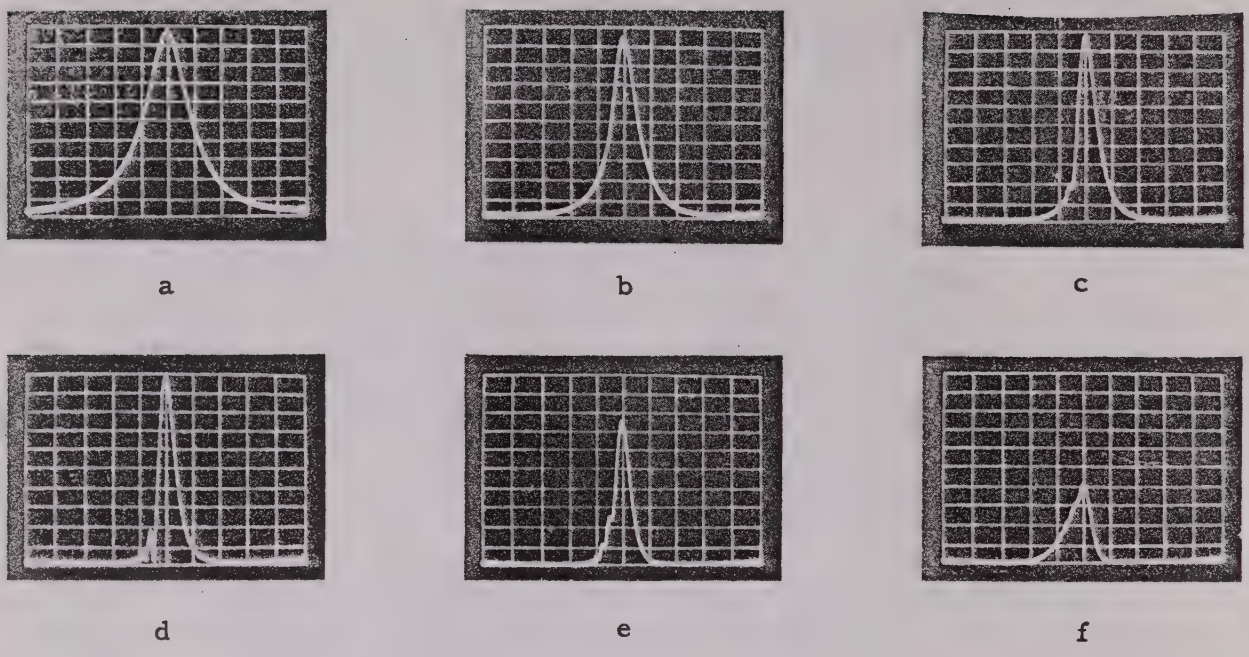


Figure III-2. Screen Presentations for Different Settings of IF BANDWIDTH Control on the Linear Amplitude Scale.

Waveforms "a" to "f" of Figure III-2 indicate progressive variations in pip shape effected by counterclockwise rotation of the IF BANDWIDTH control. In "a" and "b" the intermediate-frequency bandwidth is broad for particular scanning velocity (product of sweep rate and sweep width). Waveform "c" shows beginning of ringing. On the LIN amplitude scale, with a full-scale or smaller pip, the notch between the signal pip and ringing pip nearest the signal pip extends into the baseline when the equipment is at optimum resolution. This is illustrated in waveform "d". On the LOG amplitude scale with a greater than half-scale pip, the notch may not go to the baseline. In this case, optimum resolution is the point at which the notch is nearest the baseline. Ringing will not appear on the EXP amplitude scale. As the if section is made narrower, excessive ringing widens the signal pip and decreases the pip amplitude, thus reducing the resolving power. Further counterclockwise rotation of the IF BANDWIDTH control causes a reduction in amplitude and a tendency towards merging of the pips. This is shown in waveforms "e" and "f".

(6) To better separate the signals, the SWEEP WIDTH and IF BANDWIDTH controls can be rotated further counterclockwise and SWEEP RATE set to a lower rate. If it is mandatory to observe a given sweep width at one time and the signals contained therein are so closely spaced that they cannot be completely resolved, maximum resolution is recognized by the appearance of the clearest picture. Further counterclockwise rotation of the IF BANDWIDTH control will result in lessened resolution and a bobbing presentation. Better resolution can be obtained by looking at a narrower sweep width and then shifting the center frequency to cover the spectrum segment of interest.

e. NOISE ANALYSIS.

In noise analysis (noise being defined as randomly fluctuating signals), the same general techniques are used for setting the equipment for the spectrum of interest as are used for discrete signals.

If the input spectrum is broadband, to prevent equipment overload, it is very important to monitor the input level. See paragraph III-4b(2).

The following special techniques should be noted.

In general, a fairly wide if bandwidth is preferred for noise analysis. This permits relatively rapid scans since a wide if bandwidth gives better noise envelope averaging than does a narrow if bandwidth. However, if the noise source is highly selective (for example, influenced by a structural resonance), an if bandwidth which is narrow compared to the bandwidth of the resonance is required. This permits presentation of fine detail of the noise characteristics. When a narrow if bandwidth is used, a low sweep rate is necessary for correct amplitude presentation. The appropriateness of the sweep rate can be determined by changing the sweep rate slightly and noting whether or not there is any change in the envelope amplitude. (The portion of envelope having the greatest slope should be watched since the greatest change in envelope amplitude will occur here.) The sweep rate should be slow enough that a small change in sweep rate does not result in an amplitude change. If the sweep rate is at minimum, the sweep width should be reduced and/or the if bandwidth increased until it is possible to make a small change in sweep rate without changing the amplitude. Once a sweep which is slow enough to provide correct results has been established, a slower sweep can be used if improved envelope averaging is required.

In noise analysis, video filtering can be used to obtain averaging of the noise spectrum envelope. It is usually desirable to rotate the VIDEO FILTER control clockwise until a single-line presentation is obtained.

The video filtering should not be too great (control too far clockwise) for the setting of IF BANDWIDTH. This can be checked by changing the sweep rate slightly and noting whether or not there is a change in the most sloped portion of the presentation.

In a general sense, the if bandwidth, VIDEO FILTER setting, sweep width, and sweep rate should be such that a slight change in sweep rate does not change the slope of the most sloped portion of the presentation. If this is not the case, it may be necessary to reduce the sweep rate, sweep width, or video filtering or increase the if bandwidth.

As an alternate to envelope averaging by video filtering, photographic averaging can be used. This is simply a matter of taking a composite photograph of a number of successive scans, thereby obtaining an average presentation.

The equipment nominal sensitivity listed in Section I-5e is applicable only to discrete signals. If absolute noise amplitude measurements are required, a calibration of the analyzer using a known noise amplitude should be made. Such a calibration must be made at the same scanning velocity (product of sweep width and sweep rate) and if bandwidth used for measurement since change in scanning velocity and/or if bandwidth changes the amplitude. It is convenient to use the Panoramic Signal Alternator, Model SW-1, to display on alternate scans the calibration presentation and the analysis presentation.

f. INTERPRETATION OF TYPICAL SCREEN PRESENTATIONS.

With a little experience, the operator will be able to recognize visually the character of the various types of signals.

(1) An unmodulated constant carrier appears as a deflection of fixed height and fixed horizontal position. Reducing the sweep width broadens the pip.

(2) An amplitude-modulated carrier, with a modulating frequency lower than the resolution capability of the equipment, will appear as a deflection of variable height. Non-constant tone modulation of low frequency will produce a series of convolutions varying in height, their number being determined by the modulation frequency. The nature of the presentation will depend upon the sweep width, the sweep rate, and the if bandwidth. As the modulation frequency increases, the convolutions move toward the two sides of the deflection and the sidebands tend to become visible and it becomes

possible to separate the sidebands by increasing the resolution. The higher the frequency of modulation, the farther away the sidebands will move from the center deflections, representing the carrier. In evaluating the level of sidebands, the flatness of the spectrum analyzer over the band of frequencies involved must be taken into account.

(3) Single-Sideband Modulation appears, in general, as standard amplitude modulation with one of the sidebands suppressed. In the case of Suppressed Carrier Single Sideband the carrier is also suppressed. The suppression is, of course, not perfect, therefore, there may be some small amount of the carrier and/or the suppressed sideband present.

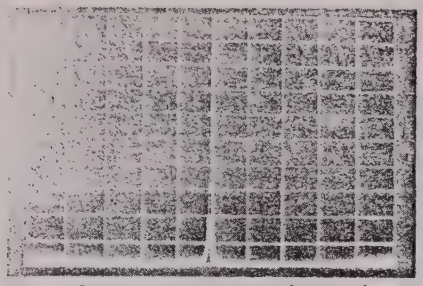
(4) A pulse-modulated signal will consist of a pattern of vertical spikes. The number of spikes is dependent on the pulse repetition rate and the sweep rate of the equipment. The amplitude of each spike represents the amount of energy present at that particular frequency during one of the pulses. The peak envelope of all the spikes represents the energy-distribution pattern of the signal. When analyzing this type of signal, both synchronous and asynchronous displays may be required in order to determine the complete pattern.

(5) Signal Interference. Two unmodulated signals which are close enough in frequency will appear on the screen as a single deflection, varying in height as with a modulated signal. By increasing the resolution capabilities of the analyzer (reducing the sweep width, reducing the sweep rate, and/or narrowing the if bandwidth), it may be possible to separate the two signals into two distinct pips.

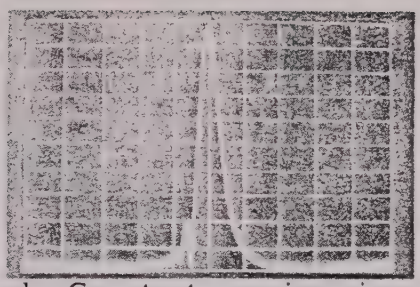
(6) Transient disturbances, generally examined, are of two types: periodic and aperiodic transients. Periodic transients, such as produced by motors, vibrators, buzzers, etc., appear as signals moving along the frequency-sweep baseline in one direction or another. Thus, an engine which is accelerating will produce a set of deflections which may move first in one direction, slow down, stop, and then move in an opposite direction. This is caused by the fact that the analyzer is sweeping at a fixed rate, whereas the transient occurs at a variable rate. The images stand still on the screen when there is synchronism between the two. If the transient disturbance is synchronized with the analyzer horizontal sweep, the "noise" appears as a fixed signal which, however, does not move on the screen when the center frequency is changed, but

only varies in height. Such deflections may appear like amplitude-modulated signals or like steady carrier. Aperiodic transients, such as static, appear as irregular deflections and flash along the whole frequency-sweep axis.

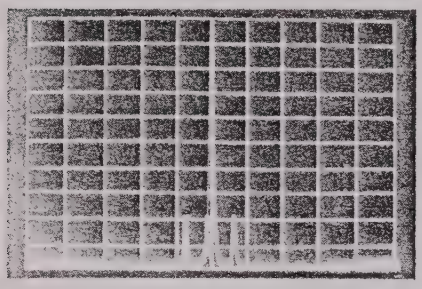
(7) Diathermy or other apparatus using an unfiltered or ac power supply will produce a periodic disturbance which will cause a deflection to appear on certain portions of the screen and disappear on other portions when the analyzer horizontal sweep is synchronized with the power line. This is due to the fact that such equipment emits a signal pulsating in synchronism with power line. On the other hand, the analyzer, too, is sweeping the spectrum in synchronism with the line, but at a lower frequency and only when a proper phase relationship exists is it possible for the analyzer to receive those periodic pulses.



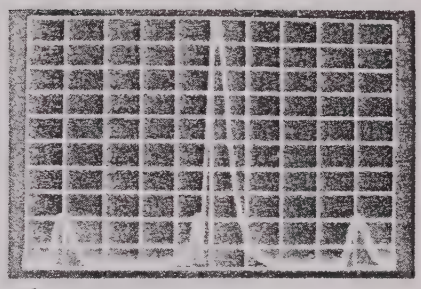
a. Constant-carrier signal at maximum sweep width.



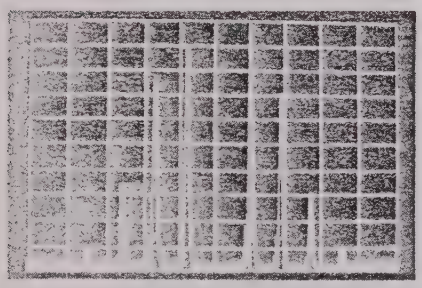
b. Constant-carrier signal at reduced sweep width.



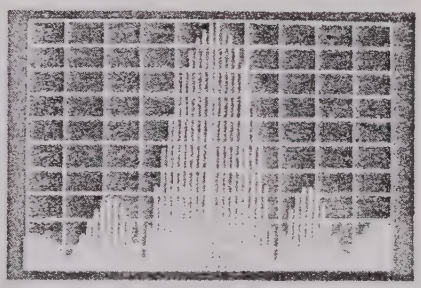
c. Am signal showing carrier at the center of the screen and two sidebands.



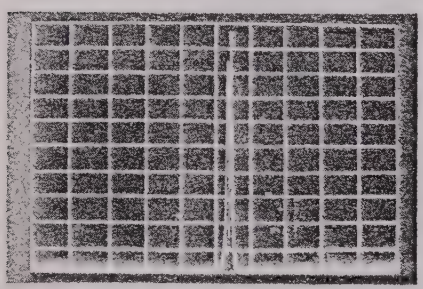
d. Same signal as "c" at reduced sweep width. Carrier remains at center of screen.



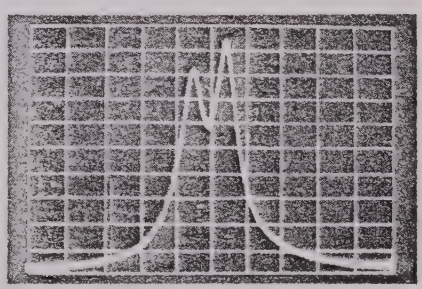
e. Frequency-modulated signal with carrier null.



f. Spikes indicating distribution of a pulsed rf signal.



g. Two interfering carriers at maximum sweep width.



h. Same signals as in "g". Sweep width reduced resulting in improved separation (resolution) of signals.

Figure III-3. Typical Screen Presentations.

CHAPTER IV
ACCESSORY EQUIPMENT

IV-1. INTRODUCTION.

This chapter contains information concerning the accessory equipment that can be used with the Panoramic Ultrasonic Analyzer, Model SB-15. Information concerning electrical and physical characteristics, applications, installation, and operation is provided.

No attempt to operate an accessory equipment should be made until the user is thoroughly familiar with the operating instructions pertaining to it.

IV-2. PANORAMIC ULTRASONIC RESPONSE INDICATOR, MODEL G-15.

a. INTRODUCTION

(1) APPLICATIONS.

Used as an adjunct to the Panoramic Ultrasonic Analyzer, Model SB-15, the Ultrasonic Response Indicator, Model G-15 provides instantaneous, direct reading, visual presentation of amplitude-versus-frequency characteristics of systems and devices in the region between 100 cps and 600 kc.

Rapid determination of the transmission characteristics of lines, filters, transformers, and kindred networks is facilitated. The combination of G-15 and SB-15 is extremely helpful for examining the response of high-fidelity audio amplifiers where flatness of response to frequencies as high as 100 kc is sometimes of interest. The system provides a rapid means for locating resonant frequencies in mechanical systems. Telemetering components, such as filters, can be readily analyzed with the G-15.

(2) GENERAL DESCRIPTION.

The Ultrasonic Response Indicator and Panoramic Ultrasonic Analyzer combination serves as a source of sweeping test-signal voltage and a synchronous selective detector. In addition to providing the speed of a sweeping signal with oscilloscope display, the combination offers several advantages of considerable importance.

Direct readings of frequency and amplitude are available on the screen of the Panoramic Ultrasonic Analyzer, Model SB-15. The SB-15 is readily conditioned to display any 1- to 200-kc portion of the band from 100 cps to 600 kc. The center frequency and width of the displayed portion of the spectrum may be varied by means of two calibrated controls of the SB-15. The SB-15 features a linear amplitude scale, logarithmic amplitude scale, as well as an expanded scale for very close amplitude comparison.

The selective characteristic of the Panoramic Ultrasonic Analyzer insures indications of the fundamental response only. The combination is therefore particularly advantageous for the study of systems in which it is difficult to obtain an adequately "clean" output, that is, systems where the presence of noise or non-fundamental components obscures or distorts the output at the exploring frequency. For example, in loops including mechanical transducers, it is difficult to translate pure sinusoidal mechanical vibration into a harmonic-free electrical signal. In such cases, the Panoramic Ultrasonic Response technique relaxes or eliminates the precautions necessary to avoid error. Since at any given time the Panoramic Ultrasonic Analyzer is receptive to only a narrow band of frequency, only the noise contained in this narrow band (rather than over-all noise) will influence the indication. This, then, reduces the problem of determining responses when the signal-to-noise ratio is small.

Basically, the G-15 functions as follows. Input signal derived from the SB-15 swept oscillator (a 1-kc to 200-kc band in the region from 1500 kc to 2100 kc) is mixed in a balanced mixer with a fixed oscillator signal (1500 kc) in the G-15 to produce, among other products of mixing, a 1-kc to 200-kc band of signals in the region of 0 to 600 kc. All other products of mixing are rejected by a 525-kc low-pass filter that couples the output of the balanced mixers to a wide-band ultrasonic amplifier. The output of this amplifier passes through a cathode follower to the output attenuators which provide 80 db of attenuation in 1-db steps.

(3) EQUIPMENT SUPPLIED.

Description	Quantity
Model G-15 including self-contained power supply -----	1
Interconnecting cable (G-15 to SB-15) ----------	1
Mating fitting for front-panel OUTPUT receptacle -----	1

(4) ELECTRICAL CHARACTERISTICS.

(a) Input Frequency.*

Any 1-kc to 200-kc band in the region from 1500 kc to 2100 kc.

(b) Output Frequency.*

A 1-kc to 200-kc band in the range of 100 cps to 600 kc. This output is a function of the SWEEP WIDTH and CENTER FREQ dial settings of the SB-15, that is, the center and width of the sweeping output will directly correspond to the settings of the SWEEP WIDTH and CENTER FREQ dials.

(c) Sweep Rate.*

1 to 60 cps, corresponding to the sweep of the SB-15.

(d) Voltage Output.**

2.5-volts rms into 600-ohm load. The flatness of output voltage is ±5% in the frequency range of 200 cps to 525 kc.

(e) Internal Load.

600 ohms (switched in or out by means of front panel control).

(f) Output Attenuation.**

80 db in steps of 1 db, providing output voltages from 2.5 volts to 250 microvolts across 600 ohms.

(g) Power Source.

117 volts, 50 to 60 cps, 70 watts.

---

* When used with SB-15.
** Voltages presuppose an input from the SB-15.

(5) PHYSICAL CHARACTERISTICS.

Panel Size	19 inches wide x 5-1/4 in. high. (The panel is slotted to fit standard 19-inch relay rack.)
Cabinet Depth	9 inches.
Interconnecting Cable	9 feet long.

(6) TUBE COMPLEMENT.

Circuit Reference Symbol	Tube Type	Function
V1	6AH6	RF Amplifier
V2	6BN6	Mixer-Limiter
V3	6BN6	Mixer-Limiter
V4	6AB4	First Ultrasonic Amplifier
V5	6AH6	Second Ultrasonic Amplifier
V6	6AB6	Oscillator
V7	6AQ5	Cathode Follower
V8	5Y3-GT	Full-Wave Rectifier
V9	OA2	Voltage Regulator

(7) OPERATING CONTROLS.

The following controls are available to the operator. They are mounted on the front panel.

(a) POWER.

This toggle switch is used to turn the power-line input to the Model G-15 on or off.

(b) OUTPUT ATTENUATION.

These seven toggle switches are used to attenuate the output amplitude of the Model G-15 to a suitable level.

(c) LOAD.

This toggle switch is used to switch a 600-ohm internal load in or out.

b. INSTALLATION.

(1) INPACKING AND INITIAL INSPECTION.

Refer to section II-1. The equipment supplied as part of the Model G-15 is listed in IV-2a(3).

(2) MOUNTING.

The equipment is supplied either with or without cabinet depending on customer order. The panel used in either case may be mounted in a standard, 19-inch electrical-equipment rack.

The equipment should be located for effective ventilation near the Model SB-15 with which it is to be used.

(3) INTERCONNECTING PROCEDURE.

Using the integral line cord, connect the Model G-15 to a source of 117 volt, 50- to 60-cps power. If a nominally 230-volt supply is available, a step-down transformer must be used.

Connect theG-15 CONN receptacle at the rear of the SB-15 chassis to the INPUT receptacle on theG-15 chassis using the supplied interconnecting cable.

A shielded output cable must be fabricated. For this purpose, a mating fitting for the G-15 front-panel OUTPUT receptacle is supplied.

(4) INSTALLATION CHECKS.

(a) G-15 Oscillator.

(i) Turn on the SB-15 and G-15. Allow a half hour warm-up period before making checks.

(ii) Set the following SB-15 front-panel controls to the listed position.

CENTER FREQ dial ---------- 0
SWEEP WIDTH dial ---------- 10 KC
INPUT ATTEN, STEP ---------- 40 DB
INPUT ATTEN, CONT ---------- Mid-rotation

IF ATTEN ----------40 DB
AMPLITUDE SCALE ----------LIN
IF BANDWIDTH ----------1/3 from extreme ccw pos.
CAL-SYNC SEL ----------LINE
SWEEP RATE ----------1 cps

(iii) Set the following G-15 front-panel controls to the listed position.

LOAD ----------IN
OUTPUT ATTENUATOR ---------- Out (all switches down)

(iv) With the G-15 output cable not connected, adjust the SB-15 R BAL and/or G BAL controls for a zero pip that is approximately one-half inch in height. Note its frequency position on the SB-15 crt screen.

(v) Connect the G-15 output cable (fabricated as indicated in IV-2b(3) above) between the G-15 front-panel OUTPUT receptacle and the SB-15 INPUT receptacle. This should result in a baseline rise that has a notch corresponding to the zero pip.

(vi) Set SB-15 INPUT ATTEN, CONT for a full-scale trace. If the frequency position of the bottom of the notch in the trace is the same as that of the zero pip in step (iv) above, then the G-15 oscillator is operating at its correct frequency. Check coincidence by removing the input to the SB-15 and again noting the position of the zero pip.

(b) Output Level.

(i) Set the SB-15 front-panel controls to the same positions as in (a)(ii) above but set CENTER FREQ dial to 10 KC and SWEEP WIDTH dial to 1 KC.

(ii) Set the G-15 LOAD to IN and G-15 OUTPUT ATTENUATOR off (all switches down).

(iii) Connect an accurate audio-frequency vacuum-tube voltmeter to the G-15 OUTPUT receptacle. An output of approximately 2.5-volts rms should be obtained.

(c) G-15 Flatness.

(i) Set the SB-15 front-panel controls as in (a)(ii) above but set IF BANDWIDTH to MAX, CENTER FREQ dial to 100 KC, and SWEEP WIDTH dial to 200 KC.

(ii) Connect the SB-15 INPUT receptacle to the G-15 OUTPUT receptacle.

(iii) Adjust the SB-15 INPUT ATTEN, CONT for a full-scale trace.

(iv) The amplitude variation of the trace should not exceed ±5%.

c. OPERATING TECHNIQUES.

(1) The operating instructions for the Model SB-15 apply when the Model G-15 is used. The G-15 serves solely as a generator of synchronous sweeping test signal.

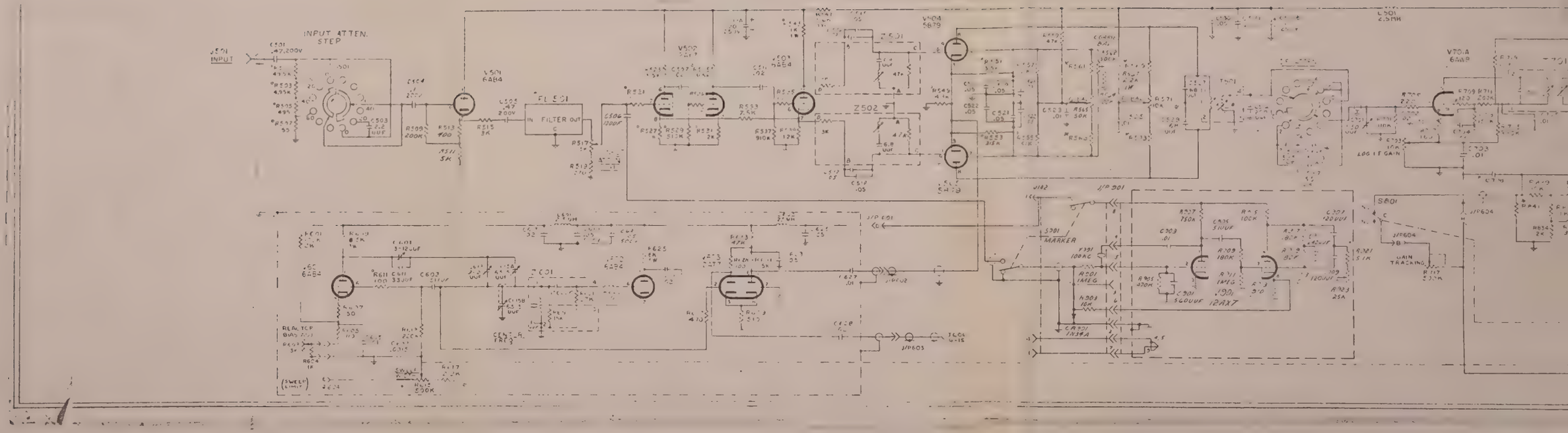
(2) Before using the G-15, SB-15 combination, a 30-minute warm-up period should be allowed. After the warm-up period, the installation checks of the G-15 oscillator, output level, and flatness given in IV-2b(4) should be made.

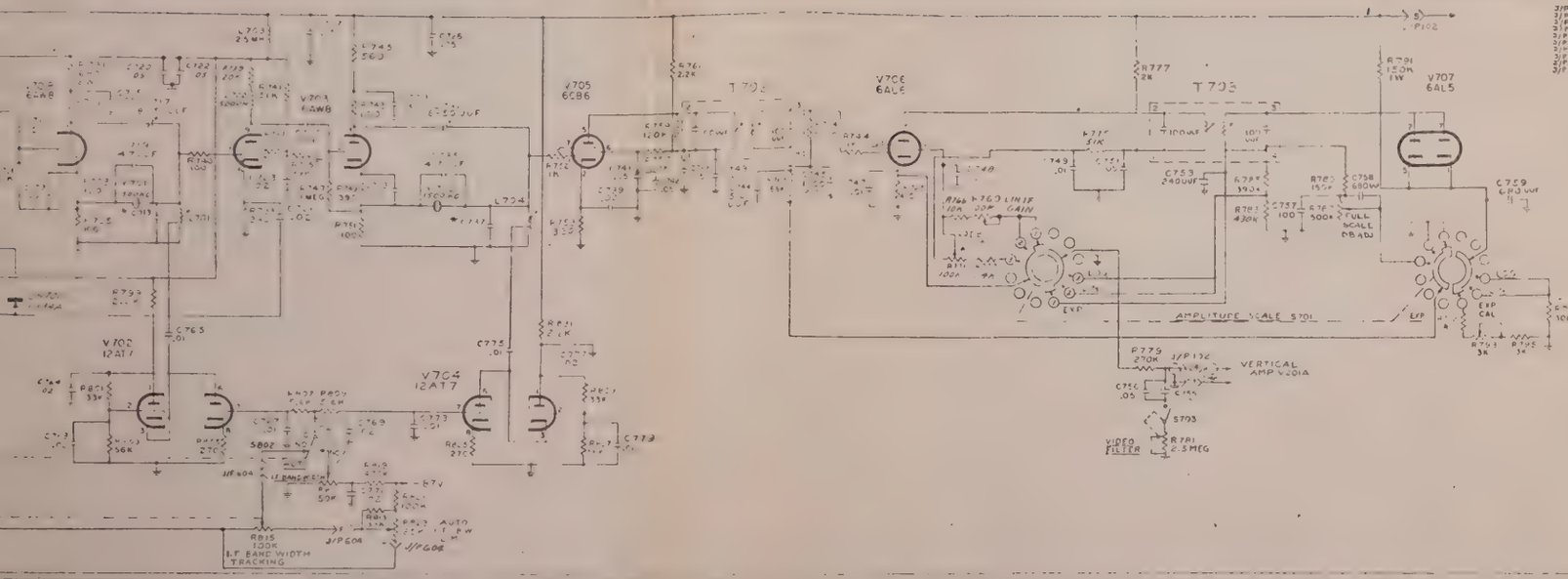
(3) Connect the G-15 OUTPUT receptacle to the input of the device to be tested. Connect the output of the device to be tested to the SB-15 INPUT receptacle.

(4) If the input impedance of the unit under test is high, then use the G-15 with the LOAD switch set to the IN position. This is of particular importance for accuracy of the low db settings of OUTPUT ATTENUATOR.

(5) Use the G-15 OUTPUT ATTENUATOR to select an output level that is suitable for the unit under test. It is possible to select an output level from the G-15 between 250 microvolts and 2.5 volts (across a 600-ohm load) in steps of 1 db by proper choice of switch positions. E.g., by setting a 2 DB and the 10 DB switch to the up position, a 12-db attenuation of the 2.5-volt G-15 output is provided to the input of the unit under test.

(6) The desired center frequency and sweep width of the output signal from the G-15 is selected by setting the SB-15 CENTER FREQ and SWEEP WIDTH dials for the desired band of frequency. The SB-15 attenuators are used to provide a suitable trace height on the crt screen of the SB-15.


INPUT ATTEN. STEP
J501 INPUT
V501 6AB4
FL 501
IN FILTER OUT
V502 6AB4
Z501
Z502
V504 5879
L501 2.5MH
V701A 6AW8
LOG I.F. GAIN
S301 MARKER
S801
MAIN TRACKING
J/P 501
J/P 801
J/P 802
J/P 803
J/P 804
J/P 602
J/P 603
J/P 604
REACTOR BIAS
(SWEEP LIMIT)
CENT. FREQ.



CONNECTORS

J/P102 POWER SUPPLY CONN
J/P201 TWT & ACCES CONN
J/P203 } INTENSITY FOCUS ASST
J/P701 SAWTOOTH GENERATOR
J/P801 W/Y SUPPLY
J/P601 }
J/P602 } SWEPT DEC
J/P603 }
J/P636 }

PART NO.	ADJUSTED TO MIN A	B	COMMENTS ADJ'D USED
R561	120K		
R563	120K		
R569	20K		
R573	20K		
C737	.1M		
C713	1G		
C708	.02		
R841	15M		

NOTES
1 UNDERLINED TITLES ARE LOCATED ON THE FRONT PANEL
2 ALL RESISTORS ARE 1/2W UNLESS OTHERWISE SPECIFIED
3 ALL CAPACITORS ARE IN UF UNLESS OTHERWISE SPECIFIED
4 * ARE 1% COMPONENTS.
5 ▲ FACTORY ADJUST COMPONENTS.

D	AS PER CO #16	CL 9153	
C	AS PER CO #15	CL 9359	

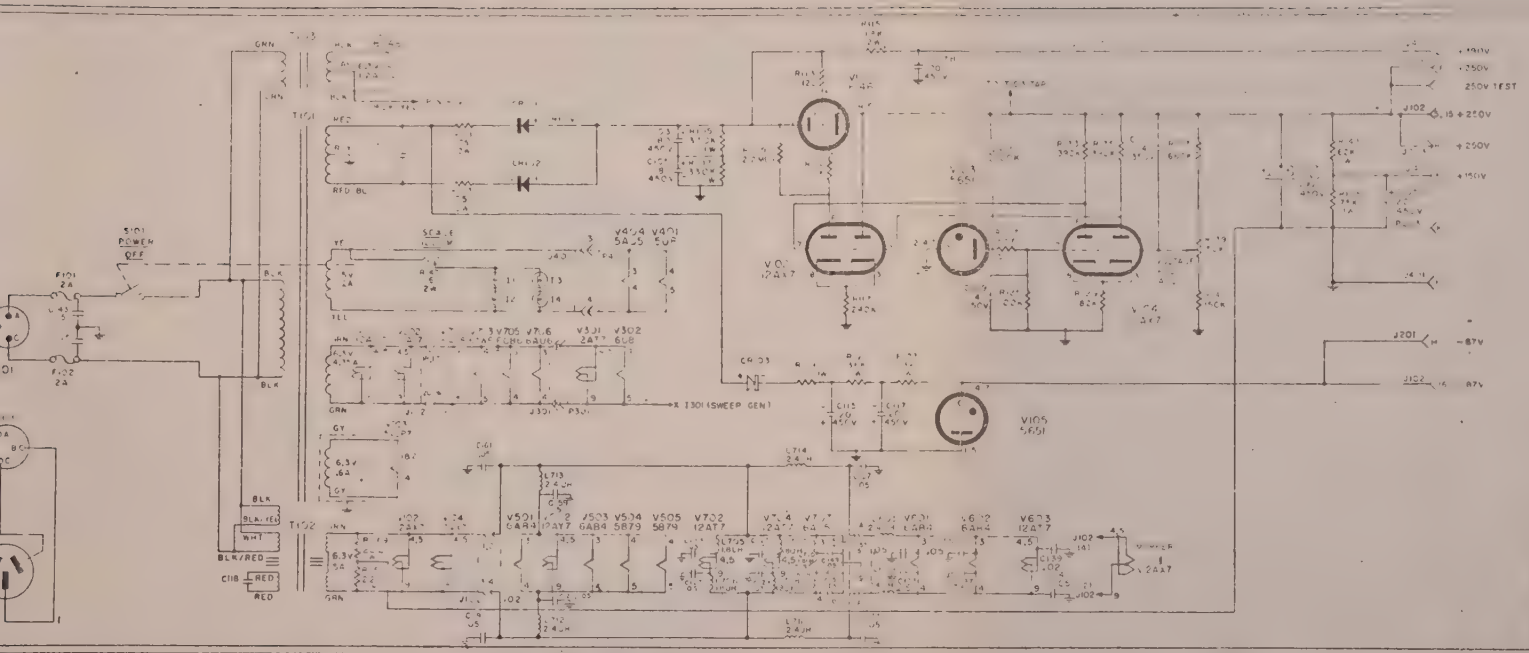
USED ON SB 4

DRAWN [illegible] 1-7-57
CHECKED [illegible] 1-7-57
ORIGINATOR [illegible] 1-7-57
MECH
ELECT
SPEC
ENG [illegible] 1-7-57

PANORAMIC RADIO PRODUCTS, INC.
MT. VERNON, NEW YORK

PANORAMIC SPECTRUM ANALYZER

SCALE ~ DRAWING NUMBER PS-15153-1

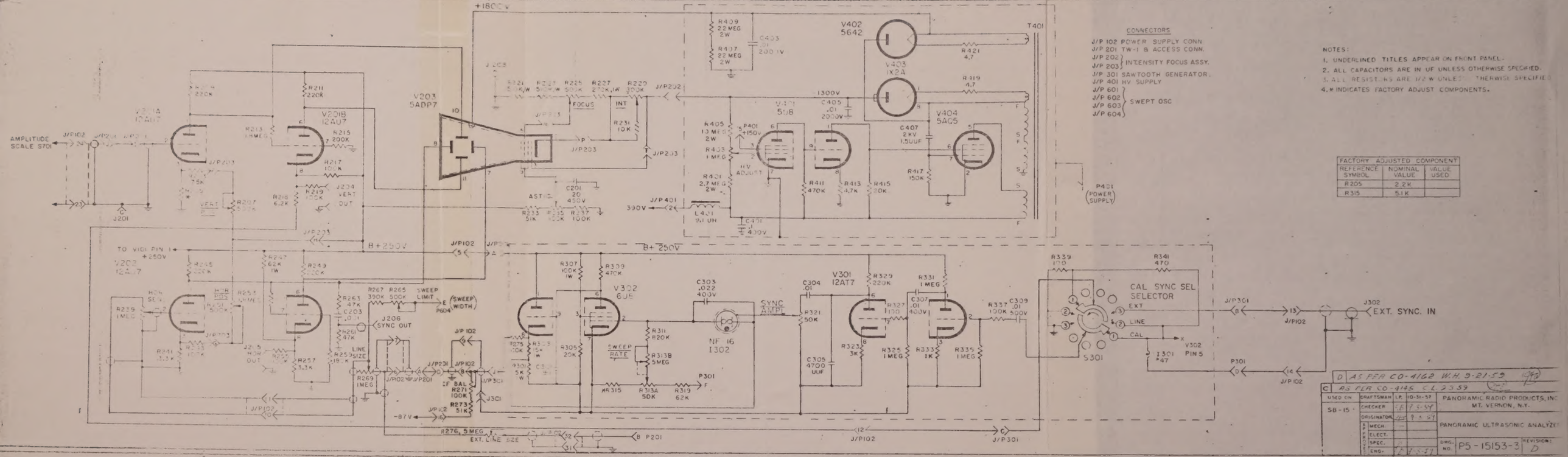


NOTES:
1. ALL RESISTORS ARE 1/2W UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE OF VALUE INDICATED OTHERWISE IN MFD.
3. UNDERLINED TITLES APPEAR ON FRONT PANEL.

CONNECTORS
J/P102 POWER SUPPLY CONN
J/P201 TM 1-B ACCESS CONN
J/P202 } INTENSITY FOCUS ASSY
J/P203 }
J/P301 SAWTOOTH GENERATOR
J/P401 HV SUPPLY
J/P601 }
J/P602 } SWEPT OSC
J/P603 }
J/P604 }

D	AS PER CC 4162 CL 9 X-9	
C	AS PER CC 4241 CL 7 X-7	

ISSUED ON	DRAFTSMAN	PANORAMIC RADIO PRODUCTS, INC
SB 11	CHECKED	SEA CLIFF, LONG ISLAND, NEW YORK
	MECH. ENG.	PANORAMIC ULTRASONIC ANALYZER POWER SUPPLY
		SIZE: A — DRAWING NO.: PS-1515[illegible]-2



FACTORY ADJUSTED COMPONENT		
REFERENCE SYMBOL	NOMINAL VALUE	VALUE USED
R205	2.2K	
R315	5.1K	

D AS PER CO-4162 W.H. 9-21-59

C AS PER CO-4145 E.L. 7-3-59

USED ON	CRAFTSMAN	I.P. 10-31-57	PANORAMIC RADIO PRODUCTS, INC. MT. VERNON, N.Y.
SB-15	CHECKER	7-3-59	
	ORIGINATOR	9-21-59	PANORAMIC ULTRASONIC ANALYZER
	MECH.		
	ELECT.		
	SPEC.		DWG. NO. P5-15153-3 REVISION D
	ENG.	9-21-59	